

AIR COMMAND AND STAFF COLLEGE

AIR UNIVERSITY

HOW THE MILITARY CAN INTEGRATE UNMANNED AERIAL
SYSTEMS IN THE CIVIL RESERVE AIR FLEET

by

Hesham H. Aly, Maj, USAF

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Proposal Advisor: Dr. Heather Marshall

Research Advisor: Dr. Robert Niesiobedzki

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ABSTRACT

The US faces significant challenges in the future in meeting multi-spectrum airpower requirements, to include combat, airlift, and other support operations. The exponential growth of unmanned aerial systems (UAS) in recent decades brings new capabilities and continues to fundamentally impact military doctrine and strategy, particularly in how civilian operators or contractors contribute to airpower. Tightened defense budgets and military personnel reductions present significant restrictions on UAS fleet acquisitions. To address future contingencies, the military must examine how it can meet airpower requirements as UAS technology continues to evolve.

The US military augments its transportation capabilities using the Civil Reserve Air Fleet (CRAF), a program proven to sustain surges in passenger and cargo airlift requirements during wartime operations. Given this successful model, this research explores and recommends expanding CRAF to include UAS for combat support and airlift roles, in comparison to a dedicated military UAS fleet or interagency augmentation. Civilian resources may provide the necessary cost advantages, technologies, manpower, and integration that will allow the US to maintain air superiority and global reach. UAS continue to benefit from research and development to expand their roles in both peacetime and wartime operations, and rapid improvements in technology in the civilian sector continue to expand possibilities for military augmentation.

INTRODUCTION

Unmanned aerial systems (UAS) offer a wide range of capabilities that will influence American military airpower strategy, operations, and organization. The roots of modern military unmanned flight date back to World War I when the US Congress approved funding for surveillance balloons that would fly over European trenches.¹ Fueled by major technological advancements, the past few decades ushered in a highly effective fleet of UAS platforms including tethered aerostat surveillance balloons, fixed-wing reconnaissance and attack-capable aircraft, and cargo helicopters. As an additionally demonstrated capability, the US Air Force placed unmanned QF-4 target drone fighter aircraft in service in 1997, retrofitted from retired F-4 Phantom II aircraft.² The next fleet of target drones, the QF-16, will enter service in 2017 under contract from the Boeing Corporation.³

The civilian sector also continues to improve upon UAS technology as more unmanned aircraft take to the skies. While commonly view by the public as nuisance recreational drones that pose a hazard to commercial aircraft, civilian UAS serve some essential functions from drug interdiction, search and rescue, hurricane observation, wildlife and park preservation, agriculture, and precision mapping.⁴ Online shopping giant Amazon began researching UAS options for package delivery in 2013 and continues to pursue approval from the Federal Aviation Administration (FAA).⁵ Additionally, cargo airlines FedEx and UPS have expressed interest in unmanned commercial jet aircraft for short, medium, and long-haul cargo transport.⁶ A highly active and motivated civilian industry driven by financial gains, and operational efficiency can yield additional capabilities in unmanned flight.

Throughout history, the relationship between the military and civilian aviation remains closely intertwined, particularly during times of war. Early civilian aviation technology benefited from government grants to design and compete for selection as military aircraft. While

military need served as the impetus for improved civilian technology, global demand for passenger and cargo transport provided a financial motive for the civilian sector to improve commercial aircraft speed, range, and efficiency rapidly. Recognizing the military could benefit from excess civilian transport capacity without staffing a large and expensive peacetime fleet, the US government commissioned the Civil Reserve Air Fleet (CRAF) after World War II.

Civil Reserve Air Fleet (CRAF) Overview

Civilian commercial aircraft play an essential role in military airlift and aeromedical evacuation. As the US entered World War II, A 1941 directive by President Franklin D. Roosevelt seized all commercial aircraft needed to augment the war effort; these civilian aircraft flew hundreds of missions over Europe.⁷ Additionally, commercial aircraft took part in the Berlin Airlift of 1948-1949, providing much-needed food and supplies to West Berlin.⁸ Finally, the Korean War highlighted deficiencies in military manning that once again required civilian airlift augmentation. As a result, the US published a Memorandum of Understanding in 1952 formally establishing CRAF.⁹ Activation of CRAF in 1990 for Operations DESERT SHIELD and DESERT STORM demonstrated US military reliance on civilian aircraft. CRAF carriers transported two-thirds of participating military personnel and 25 percent of airlifted cargo to the combat zone and brought home 85 percent of military personnel and 42 percent of the cargo.¹⁰ The US similarly relied on CRAF activation during Operation IRAQI FREEDOM in 2003, transporting 100,000 personnel in four months.¹¹

While operational surges requiring activation historically remain infrequent, the peacetime contributions of participating civilian commercial carriers indicate the US military relies heavily upon the CRAF program. The US Department of Defense (DOD) contracts with CRAF carriers to transport 90 percent of its personnel and nearly 40 percent of its cargo.¹² Lower cost remains the key factor in CRAF utilization over procurement of military assets. The

2003 activation of CRAF for IRAQI FREEDOM cost the US government \$1.5 billion for the use of those commercial aircraft, a mere fraction of the \$15 to 50 billion estimated cost of using purely military or DOD airlift.¹³ CRAF participants bear the responsibility of providing both the aircraft and the operating crew, as well as maintaining the aircraft.

Category	Section	# Aircraft
International Long-Range	Passenger	147
	Cargo	130
International Short-Range	Passenger	134
	Cargo	5
National Domestic Services	Passenger	1
	Cargo	36
Total Aircraft		453

Table 1: Current CRAF Fleet Composition¹⁴

Currently, the US government maintains access to over 450 total CRAF commercial passenger and cargo aircraft.¹⁵ This allocation equates to more than double the entire fleet of 223 Air Force C-17A Globemaster III transport aircraft.¹⁶ In addition to saving on acquisitions, maintenance, training, and crew costs, the military benefits from access to modern aircraft, and highly experienced commercial pilots, readily available upon activation or through peacetime contracts. The commercial aviation industry can translate its research and development (R&D), testing, and safety improvements to the military through the CRAF partnership.

Nature of the Problem

The DOD must streamline and optimize its armed forces to comply with constrained budgets. The Office of Management and Budget (OMB) reports a DoD budget of approximately \$524 billion in fiscal year (FY) 2017, a 20 percent decline since peak defense spending in 2011.¹⁷ Forecasts for future defense spending indicate inflationary increases, while authorized end personnel strength for the armed forces will continue reducing from three million in 2010 to just above 2.6 million total soldiers, sailors, Airmen, and marines in 2017.¹⁸ This downward trend characterizes a US military drawdown from 15 years of continuous wartime operations.

For future airpower contingencies, the US government continues to fund UAS development and train operators for those aircraft.

UAS implementation in military operations provides efficiencies to offset reductions in funding and personnel. However, the increasing utilization rates of UAS in various ISR missions has stretched military personnel and resources thin. General Atomics, a California-based defense contractor, produces the highly successful MQ-1 Predator and MQ-9 Reaper UAS platforms. In addition to UAS production, General Atomics contracts its civilian UAS pilots to the military to deploy as needed worldwide. Despite the aging technology of the Predator, operational requirements have kept it in service years beyond the originally projected retirement date. Additionally, the popularity and combat effectiveness of the Reaper resulted in a one-year lease of a Reaper staffed with civilian pilots, sensor operators, and support crew as recently as April 2015.¹⁹ This unprecedented use of civilian-owned UAS and civilian crews marks a major paradigm shift driven by cost and manning constraints. Civilian-controlled Reaper combat patrol assignments will grow from two missions per crew per day today to ten missions per day in 2019 due to lack of available military UAS pilots.²⁰

Purpose of the Study

This study addresses some possible courses of action for meeting future UAS inventory and staffing levels for both peacetime and contingency operations. In the face of constrained budgets and a limited workforce, the US Department of Defense (DOD) must determine how to adequately meet airlift, air combat, and air combat support requirements in future contingencies. As CRAF airlines explore the possibility of cargo UAS, the DOD may consider the feasibility of adding these UAS to CRAF as technology permits. Air combat and combat air support pose more of a challenge to the US military given financial constraints and a large number of support personnel required to operate UAS missions. An already established civilian contractor presence

in combat UAS, from ISR to attack missions, sets a precedent for such operations in the future, but must be carefully evaluated for legal and financial reasons. Additionally, the concept of maintaining these UAS platforms in civilian reserve status to reduce financial obligations and personnel requirements during peacetime could be mutually beneficial to both the US government and civilian operators.

Research Question

CRAF represents a successful marriage of military and civilian assets to balance airlift capability and budgetary limitations. The track record of CRAF, which includes both passenger and cargo airlines, lends itself to the possibility of expanding the program to include UAS. The military currently employs UAS in combat and combat support roles to include intelligence, reconnaissance, and surveillance (ISR), and limited intra-theater airlift missions. While CRAF operators do not engage in direct combat, they perform combat support airlift into combat zones. Military UAS operations have heavy influence from the civilian sector, from civilian-built aircraft to civilian contracted pilots and support personnel. Based on this construct, Should the Civil Reserve Air Fleet (CRAF) program be expanded to include unmanned aerial systems (UAS) for wartime combat, airlift, and support operations?

Research Methodology

This research paper will use the problem/solution framework to find a suitable course of action for future distribution of UAS assets. The problem is defined as how to meet military unmanned aircraft inventory and staffing requirements under a constrained budget. Under the problem/solution framework, measurable criteria such as manning, cost, and operational performance will provide a logical means to compare alternative solutions. The most suitable alternative will be selected, and a recommendation for implementation will tie together the

findings of this research. The various functions of UAS may be separately analyzed to determine if any or all UAS operations could feasibly be assigned to CRAF.

Quantitative analysis serves as the primary evaluation criteria using historical and projected cost, performance, and personnel data. Additional subject matter expert input provides qualitative analysis regarding the relationship between civilian and military UAS operations. Current technological limitations and future expectations will be assessed to forecast timelines for mainstream UAS implementation in the civilian sector. The analysis of possible alternatives will include a comparison of implementation timelines along with cost advantages. Legal implications of civilian involvement across the range of military operations will also play a role in the analysis to determine the feasibility of employment. The recommendation for how the US military will address UAS fleet plans will incorporate qualitative and quantitative analysis and balance technological, timeline, and legal considerations.

LITERATURE REVIEW

A variety of primary and secondary sources over the span of a half-century provide a vital foundation for forecasting the next iteration of UAS implementation in combat, combat support, and airlift operations. Cost, personnel, and performance data will identify strengths and deficiencies in DOD UAS utilization and inventory. Publications for civilian UAS, while relatively limited due to the infancy of the civilian UAS lifecycle, allow for an in-depth analysis of existing and potential functions, utilization rates, cost, and R&D. Subject matter expert discussion also plays a role in evaluating and forecasting the future of civilian UAS. Ultimately, this research study seeks to determine functional commonalities between military and civilian UAS missions to determine whether a civilian augmentation allows for a feasible and cost-effective alternative to the military UAS inventory. The CRAF program serves as the

administrative structure that will allow the military to readily tap into civilian unmanned resources in response to a contingency or increased operational tempo.

Military UAS: Past, Present, and Future

Since the late 1950s, the US military has shown significant interest in employing UAS in the form of a multi-role platform. In particular, the Air Force developed several remotely piloted vehicles (RPVs) during a decade-long fascination with unmanned flight that ultimately faded away by 1980. The Ryan Q2-C Firebee “Lightning Bug” was first designed in 1958 and later entered service during the Vietnam War as an airborne-launched reconnaissance drone.

Variations of the Q2 measured up to 30 feet long with a wingspan up to 32 feet, an altitude capability up to 50,000 feet, and range of 1,300 nautical miles.²¹ The Lightning Bug required up to 30 personnel to operate a single mission, limiting its use to approximately once per day in Vietnam; the price tag of \$100 million coupled with maintenance and operations expenses of \$250 million per aircraft proved too costly for a capability that yielded only 50 percent target acquisition.²² Its limited success stems largely from lagging technology in camera resolution and navigation systems. Aerodynamic capabilities made the Lightning Bug well ahead of its time. In similar fashion, UAS projects of the 1970s would ultimately face cancellation while the Air Force struggled to understand how to employ the new unmanned technology. Despite failing to gain traction, unmanned aircraft flew over 3,500 combat sorties during the Vietnam War.²³

The US Navy’s interest in unmanned anti-submarine reconnaissance aircraft in the late 1980s resulted in the medium altitude Amber and the high altitude Condor. Designed by inventor Abraham Karem, the Amber successfully flew at altitudes above 25,000 feet with a duration of over 40 hours as an early predecessor for Karem’s hugely successful MQ-1 Predator.²⁴ The Condor, produced by Boeing, reached an altitude of over 67,000 feet and remained aloft for 60 hours, with a design capability to fly continuously for seven days.²⁵ Both

UAS platforms eventually failed to achieve operational status due to lack of support and high costs. In addition to the military application, Boeing designed the Condor with the civilian sector in mind for weather observation or atmospheric research. These canceled UAS programs indicate that the unmanned aviation industry once again suffered from being ahead of its time, but the expansion to civilian customers in the high altitude fixed-wing UAS market marked a major paradigm shift.



Figure 1: MQ-1 Predator and Boeing Condor

The successful use of UAS during the 1990s mitigated some reluctance to pursue unmanned technology further. The CIA successfully deployed two GNAT-750 ISR platforms, the next iteration of Karem's Amber project, to Bosnia in 1993.²⁶ The Air Force later used three first-generation MQ-1 Predators over Bosnia in 1995, ending its 16-year hiatus from employing unmanned aircraft.²⁷ Without a formidable ground troop presence in the Balkans, the US recognized the value of UAS for limited-scope military missions. The highly effective Predator operation expanded quickly, as 39 Predators flew over 6,600 combat hours over Bosnia, Kosovo, and Iraq.²⁸ By the end of the decade, the Air Force committed dedicated resources to UAS R&D, including commissioning stand-alone UAS reconnaissance squadrons and investing in the high altitude RQ-4A Global Hawk. The Predators remain in service despite their age as the Air Forces investigates replacement technology, while the high-cost Global Hawk fleet will continue to upgrade and expand to meet future requirements. The Navy variant of the Global Hawk, the MQ-4 Triton, will enter service in 2018 with an initial order of 68 aircraft.²⁹

Aircraft	Initial Production	Altitude (feet)	Endurance (hours)	Mission
Ryan Q2-C Lightning Bug	1958	50,000	1.2	ISR
Ryan AQM-91 Firefly	1962	55,000	4.5	ISR
Boeing YQM-94 Gull	1973	52,000	17	ISR, Communications Relay
IAI Scout	1977	15,000	7.5	ISR
Boeing Condor	1988	67,000	60	ISR, Weather, Atmospheric Research
General Atomics MQ-1 Predator	1994	25,000	20	ISR, Strike
Northrop Grumman RQ-4 Global Hawk	1998	60,000	40	ISR
General Atomics MQ-1 Predator	2001	50,000	27	ISR, Strike

Table 2: Military Fixed-Wing UAS Progression³⁰

The chronological data from UAS development and production collected over the course of a half a century indicates that physical capabilities play a very small role in the relatively slow progression of UAS. Achievements in speed, altitude, endurance, and reliability occurred early in the rollout of fixed-wing unmanned aircraft. A universal lack of vision caused the failure to move forward with early UAS adoption.³¹ The altitude, speed, and endurance records that many UAS would set as the technology improved could not create enough momentum for revolutionary military application. While many military leaders saw the capabilities of UAS, they could not effectively understand how to employ or benefit from them. A reluctance to accept change can constrain the armed forces as new technologies emerge. However, in the case of UAS development, the military continually attempted to pursue unmanned flight without developing a strategic roadmap.

The wartime environment since the September 11th, 2001 attacks has seen a drastic increase in military UAS operations. The DoD UAS inventory increased 40-fold between 2002 and 2010, from 167 aircraft in 2002 to 7,800 aircraft in 2015, while the budget is increased from under \$700 million in 2001 to \$6.5 billion in 2015.³² This sharp increase in UAS procurement indicates a critical shift in vision for future contingencies spanning the range of military operations (ROMO). The realization of the multi-role potential of UAS comes as other technologies catch up to the advanced concept of unmanned flight. Early UAS platforms suffered from navigation inaccuracies and limited line-of-sight control. The addition of global positioning satellite (GPS) navigation and satellite communication datalink now allows UAS to fly globally with pinpoint accuracy using redundant control capabilities. Additionally, technological improvements in imaging equipment and munitions allow UAS to perform high precision ISR and strike missions at low, medium, and high altitudes. The analysis of the expanding budget for ISR includes a major production increase, continued R&D, and enhancements to UAS payloads (cameras, countermeasures, and communication equipment). Continual block software and hardware upgrades allow older platforms to remain in service.

UAS Group	Category	Weight	Altitude	Speed
Group 1	Micro/Mini Tactical	< 20 lbs	< 1,200 feet	< 100 knots
Group 2	Small Tactical	< 55 lbs	< 3,500 feet	< 250 knots
Group 3	Tactical	< 1,320 lbs	< 18,000 feet	< 250 knots
Group 4	Persistent	> 1,320 lbs	< 18,000 feet	Any
Group 5	Penetrating	> 1,320 lbs	> 18,000 feet	Any

Table 3: DOD UAS Classification³³

The current DOD UAS fleet continues to grow, with projections totaling over 9,300 aircraft by 2017.³⁴ UAS classifications consist of five categories based on gross weight. The majority of military UAS fall into Group 1, with over 7,000 hand-launched RQ-11 Raven aircraft used for

low-altitude tactical ISR.³⁵ This analysis primarily focuses on UAS in Groups 3 through 5, with a 15-year growth of 950% to an estimated 1,235 aircraft by 2017. These larger, more capable UAS absorb much of the UAS budget due to their high acquisition cost and personnel required support and maintain their operations. Nine additional Global Hawks will bring the fleet to 67 by 2017, with a price tag (including R&D) of over \$222 million per unit.³⁶ The Reaper fleet will grow from 229 to 256 aircraft, with a unit cost of \$31 million.³⁷ This represents a one-year acquisition cost of over \$2.8 billion for Group 5 UAS alone.

Budget constraints will play a significant role in determining the composition of the future military UAS fleet. From a policy perspective, the DOD's *Unmanned Systems Integrated Roadmap FY2013-2038* provides the strategic outline for UAS with a primary focus on cost and sustainment. Lifecycle costs will decrease through commercially available products, while logistics will improve through contractors and partnerships. Recognizing the costs in shifting technology to UAS, the DOD emphasizes that "the use of tools such as public/private partnerships (PPPs) and performance-based logistics contracts should be explored as methods to reduce sustainment and infrastructure costs."³⁸ As traditionally manned aircraft reach their retirement, Congress may redirect some or all of those associated budgets to fund UAS to alleviate early lifecycle costs. The projected UAS fleet size deliberately remains unstated; the end strength will rely on future defense spending, which is expected to remain flat.

Civilian UAS

The multitude of UAS roles continues to attract interest in the civilian market as improvements in cost, staffing, and performance enables additional capabilities. Civilian UAS comprises a relatively new domain in comparison to the military development and utilization. As a relatively young technology, the growth of civilian UAS will rely on the mitigation of barriers to entry: cost, authorization to operate in the national airspace system, performance, and

reliability. UAS manufacturers now look beyond military contracts to target an expanding civilian customer base. Government agencies ranging from the National Aeronautics and Space Administration (NASA) to Customs and Border Protection (CBP) fly civilian variants of popular UAS platforms for research, observation, reconnaissance, and surveillance. As unit production costs decrease, civilian UAS platforms will gain traction with early adopters for both private and public use.



Figure 2: CBP Civilian MQ-9 Predator B Fleet³⁹

While new UAS aircraft emerge, R&D continues to convert existing manned aircraft of all types to remotely piloted versions. The successful retrofits by British Aerospace and the Boeing Corporation of retired Air Force aircraft (QF-4 and QF-16) demonstrate the ability to refurbish aircraft to remove the onboard crew successfully. While the military utilizes this technology for target drones, the civilian sector seeks to achieve similar results for existing aircraft. In 2012, Aurora Flight Services successfully modified a Diamond DA42 light twin-engine four passenger airplane to an unmanned version named the Centaur; it flew in US airspace for the first time in 2015.⁴⁰ The Centaur can transport passengers to small remote airfields or conduct low-level ISR with an onboard sensor package. Taylor Butterfield, the founder of SkyTap Inc. and former General Atomics UAS pilot, highlights the conceptual significance of automating existing manned aircraft. “Any airframe could be modified into a UAS if the need is great enough. It would make sense that first-generation cargo UAS will simply be an iteration of transport aircraft in use today.”⁴¹

Unmanned flight in the civilian market will expand beyond variants of military platforms. R&D in the civilian sector will yield new UAS platforms to address the demand for cargo, and further into the future, passenger transport. With 89 UAS manufacturers in the US, the research and production focus will shift from small recreational drones to larger commercial platforms.⁴² Global civilian UAS production forecasts show tremendous growth from \$4 billion annually in 2015 to over \$14 billion in 2025.⁴³ Current civilian demand for UAS primarily centers on imaging. Commercially available UAS provide low-cost solutions for agricultural monitoring, while sparsely populated farmland provides a haven for their operation without safety or airspace concerns. UAS with imagery equipment onboard also provide law enforcement augmentation, topographical mapping, surveillance and monitoring of oil and gas pipelines, monitoring of power lines in remote areas, TV or movie filming.⁴⁴

Additional civilian UAS projects venture beyond traditional designs and will serve in unique roles to provide airborne data relay. Google's Solara 50 and Facebook's Aquila high altitude solar-powered UAS platforms represent pioneer technology that will attract more UAS R&D and broaden the scope of potential uses for unmanned flight. The Solara 50's large wingspan of 164 feet will allow for sustained flight at 65,000 feet and will stay aloft for months providing high-speed internet relay and imaging capability worldwide.⁴⁵ The Aquila, with an altitude capability of 60,000 feet and an endurance of three months, will fly over remote areas to provide internet access to remote or underdeveloped regions.⁴⁶ While the design of the Solara and Aquila and scope of their missions may limit additional roles, the civilian UAS community will benefit from advanced R&D that will allow for further enhancements in UAS technology. The relay and communications capability of a worldwide network of high altitude and long endurance UAS will also present opportunities for commercial and military customers to acquire or lease bandwidth in various geographic locations. This category of high altitude solar UAS

technology replicates the functions of space satellites with much lower design and sustainment costs, and greater control over geographical coverage.

Helicopters and Lighter-Than-Air UAS

The future of unmanned flight will include a variety of aircraft types, including helicopters and lighter-than-air UAS (blimps and balloons). The demonstrated capabilities of unmanned helicopters include cargo and personnel transport, firefighting, humanitarian aid, search and rescue, and forestry services.⁴⁷ The helicopter multi-role mission allows for commonality between the military and civilian sectors, making a UAS variant attractive to both markets. The Lockheed Martin K-Max UAS, modified from a manned Kaman K-Max helicopter, provides the US Marine Corps with vital tactical cargo delivery in challenging terrain. The K-Max UAS entered service in Afghanistan in 2011, with a payload capability of up to 6000 pounds and an endurance of 12 hours.⁴⁸ In the first two years of service, two K-Max unmanned helicopters delivered over 3.2 million pounds of supplies.⁴⁹



Figure 3: Lockheed Martin K-Max Cargo UAS

UAS helicopters provide the US Navy with significant sea-based capabilities. The MQ-8B/C Fire Scout, adapted from the civilian Schweizer 333 and Bell 407 helicopters, can perform a wide range of missions including ISR, attack, and resupply. The Fire Scout can take off and land on Navy Littoral Combat Ships and remain airborne between five hours (MQ-8B) and twelve hours (MQ-8C).⁵⁰ DOD budget projections include plans for up to 37 Fire Scouts to bolster maritime ISR capability.⁵¹ Unmanned helicopters will remain popular in future applications for their vertical takeoff and landing capability, maneuverability in challenging terrain, and relatively low operating costs.

Lighter-than-air UAS will add unconventional transport and surveillance capabilities using advanced technology to revolutionize a previously obsolete platform design. The use of airships or blimps historically faded away due to the impractical nature of lighter-than-air flight. Large, very slow-moving, limited payload designs rendered most airships obsolete, while safety concerns created a negative public perception. Current airship development includes the unmanned Airlander 10 Hybrid Air Vehicle (HAV), which measures 302 feet long and will carry a payload of 7,000 pounds with an endurance of 21 days.⁵² The Airlander 10 began its life as a failed US Army project called the Long-Endurance Multi-Intelligence Vehicle (LEMV).⁵³ Similar airship projects will create opportunities for long-haul cargo routes for non-critical or routine shipments. Large unmanned airships will provide a cost effective alternative to oceanic or transcontinental shipping route that can benefit both civilian and military customers.

The resurgence of aerostats for military operations indicates that basic balloon technology will continue to fulfill mission gaps. Aerostats maintain a stationary position, tethered to the ground while providing surveillance and environmental data. The CBP Tethered Aerostat Radar System (TARS) enables effective drug interdiction operating at 12,000 feet, with a radar footprint of 230 miles and a capability to remain aloft for months.⁵⁴ Recognizing the

civilian surveillance capability, the military deployed civilian aerostats to Afghanistan and Iraq, including 60 large platforms and 300 smaller TCOM Rapid Aerostat Initial Deployment (RAID) systems; these aerostats allow for full-time tactical surveillance, communication relay, and acoustic attack detection.⁵⁵ DOD aerostat development and acquisition spending between 2007 and 2012 exceeded \$5 billion, with peak spending occurring in 2010 for the larger Persistent Threat Detection Systems (PTDS) and Persistent Ground Surveillance Systems (PGSS).⁵⁶

ANALYSIS

The growth of UAS in both military and civilian environments requires sustained demand, funding, and R&D. Technological breakthroughs in communication datalink, coupled with improvements in aircraft performance, continue to expand potential UAS functions. UAS will not only serve in traditional roles once only possible in legacy aircraft; they will achieve previously unattainable milestones without a crew on board. These achievements include high G-force maneuvers currently unsustainable to humans, as well as improving upon existing capabilities of flying at high altitudes with aloft times up to several days or weeks. The outlook for how the military and civilian aviation sectors will embrace and incorporate UAS will primarily impact the alternatives available in exploring future relationships. Data analysis of recent UAS technology and expansion will serve to extrapolate future demand and utilization. Military strategic planning reviews, an expert interview, and analysis of civilian UAS projects aid in exploring alternatives.

The use of CRAF as a viable domain for UAS assets primarily relies on quantitative analysis of capacity, cost, and workforce. Historical CRAF data substantiates the augmentation capabilities of the civilian commercial aviation industry, which will serve as a basis for investigating adding UAS. CRAF aircraft must meet a minimum stated availability, capability, and reliability to earn consideration for military augmentation. An estimated timeline for

availability and implementation of future civilian UAS technology will be assessed based on current publications that evaluate R&D and production forecasts. The use of UAS within CRAF can occur under the current fleet agreement if CRAF airlines acquire UAS fleets. This research paper explores additional UAS functionality to include combat and combat support operations beyond the current CRAF role of passenger and cargo airlift.

Evaluation Criteria

Alternative Solutions	Evaluation Criteria
Dedicated Military UAS Fleet	Cost
Interagency Augmentation	Personnel
CRAF Augmentation	Interoperability

Table 4: Alternative Solutions and Evaluation Criteria

Three evaluation criteria will support a recommendation to address future military UAS requirements: cost, personnel, and interoperability. Cost considerations will reflect the historical and projected military budget for UAS R&D, acquisition, operations, and maintenance. Additionally, the R&D and unit costs of commercially available UAS platforms will determine the feasibility of military acquisition of existing civilian platforms or pursuit of contracts with commercial operators. An assessment of estimated retrofit costs of manned commercial aircraft balanced against the cost savings with fewer pilots or ground-based operators will also provide supporting data for an optimum solution. Projected costs for new UAS platforms under development modeled from prior projects will serve to explore future military fleet plans or civilian contracts.

Personnel requirements play a critical role in building the defense UAS inventory. The analysis of personnel primarily accounts for the DOD military end strength authorizations as the next major constraint after defense spending. Staffing requisites include UAS pilots or other crewmembers and support personnel required for operations and maintenance. The analysis will

include the number of personnel required to successfully operate a military mission from preparation, takeoff, specific airborne functions, and recovery of UAS aircraft. The utilization of a single crew or support team to operate multiple UAS simultaneously will create efficiencies for UAS operations, and any differences between civilian and military operations will have an impact on selecting a potential solution. Training timelines, availability of mission-ready personnel, and geographic considerations will also have a measurable effect on staffing. This research evaluates the increase in personnel requirements resulting from military contingencies.

The third evaluation standard, interoperability, will address how potential UAS solutions will integrate within the military. The military can only contract civilian aircraft that can accomplish desired combat support or airlift objectives. A compatible UAS must meet minimum capability requirements, as well as operate in contingency environments. Civilian UAS platforms for ISR, combat support, and transport operations will require clearance of personnel to operate under the military command structure. For contingency operations, evaluation of interoperability will include activation timelines for entering UAS fleets into service. The compatibility criteria will further focus on different combat support operations to identify which areas of operations allow for civilian UAS involvement. Legal considerations will play a significant limiting role in determining the scope of civilian involvement, particularly in combat and combat support operations. The precedent set by existing CRAF agreements and civilian contracts in contingency environments will serve as the backstop for gauging interoperability of civilian UAS in environments that could create combatant status implications.

This research recognizes that the selected evaluation criteria, while ideally measured individually with all other variables held constant, will likely have an effect on one another. As an example, increased crew staffing requirements for a large standing military UAS force will negatively impact cost and positively mitigate interoperability concerns. Similarly, reduced

budgets set by DOD will reduce available personnel and trigger additional civilian involvement, thus driving up interoperability or compatibility limitations. Historical data for standing peacetime forces referenced against forces required for contingency or wartime operations provide a reasonable benchmark for future fleet and personnel surge requirements. CRAF utilization rates will include current peacetime contracts and phase-by-phase activation capability, applied to potential UAS fleet alternatives. The optimum alternative balances the performance measured by the three evaluation criteria against real-world constraints.

Commonality Between Military and Civilian Missions

The common functions of civilian and military aircraft allow for mission execution based on aircraft performance and capability rather than the specific type of aircraft itself. DOD contracts for aircraft types in the CRAF fleet that may not exist within the military inventory, while similarly, many military aircraft do not have a civilian equivalent. The Air Force strategic airlift fleet, for instance, consists of C-5 and C-17 aircraft, neither of which has a commercial variant. However, to satisfy military CRAF airlift requirements, aircraft such as the Boeing 747-400 freighter variant and McDonnell Douglas MD-11 passenger aircraft accomplish military cargo and personnel transport roles. Some civilian aircraft can accommodate oversized cargo that may otherwise only fit on military airlifters. For UAS applications, similar considerations will apply in gauging the capability of a civilian platform to accomplish a military mission. The analysis expects civilian UAS already in military service can continue in those roles.



Figure 4: CRAF operator Atlas Air loads a Mine Resistant Ambush Protected Vehicle (MRAP)⁵⁷

When possible, the military can access civilian UAS resources of the same type or model. Similar to the current Air Force contract for civilian General Atomics MQ-9 platforms, a civilian version of the RQ-4 Global Hawk operated by NASA can augment military missions. The precedent set for NASA involvement in defense operations includes multiple NASA civilian WB-57 aircraft deployments to Afghanistan and Africa for high altitude communications relay and optical sensing under the Battlefield Airborne Communications Node (BACN) program, flown by civilian pilots.⁵⁸ Similarly, the BACN contract provides the armed forces with three Bombardier BBD-700 Global Express aircraft, re-designated the Air Force E-11, staffed with civilian payload operators and support staff, but flown by Air Force pilots.⁵⁹ These existing relationships and prior uses of manned civilian aircraft in combat-support operations provide a proven model for future potential UAS implementation.

Alternative 1: Dedicated Military UAS Fleet

In the purest application of military force, leaders assign military personnel and use military assets to accomplish a given mission. In a general peacetime environment, personnel staffing and equipment inventory should satisfactorily meet minimum readiness and capability levels. The congressionally-mandated DOD drawdown will reduce the total armed forces end

strength from over three million active duty, national guard, reserve, and DOD personnel in 2010 to 2.6 million by 2017, representing a prior contingency personnel surge of fifteen percent.⁶⁰ Civilian positions within the armed forces will reduce to 567,000 by 2017, accounting for 21 percent of total DOD end strength.⁶¹ To address future contingency requirements, a fifteen percent increase in crew staffing will serve as the baseline for evaluation.

Over 35,000 pilots serve in the armed forces, primarily in manned multi-pilot aircraft.⁶² As military pilots earn a wide range of pay based on rank and time in service, DOD-wide data collection indicates the government spends \$138,793 annually for pilot salaries.⁶³ This average includes flight pay, housing and subsistence allowances, and pilot bonus payments. This average excludes costs associated with travel, such as lodging and per diem. At a crew availability requirement of five pilots per aircraft, the UAS staffing requirement for larger platforms (Groups 4 and 5), based on a 2015 inventory of 579 aircraft, amounts to 2,895 UAS pilots required. The growing inventory of large military UAS results in a requirement for 3,355 pilots. The fifteen percent surge scenario would incur a pilot salary cost of nearly \$70 million.

Timeline	Large UAS Inventory (Group 4 and 5)	Large UAS Cost ⁶⁴ (\$ Billion)	Military UAS Pilots	Pilot Cost (\$ Million)
2015	579	2.45	2,895	401.8
2017 (Forecast)	671	2.85	3,355	465.7
15 Percent Surge	772	3.28	3,858	535.5

Table 5: Large Military UAS Fleet and Personnel

The large military UAS data highlights the cost of owning and operating UAS as the most significant restricting factor in expanding the fleet. A dedicated military UAS fleet requires over 100 additional large UAS platforms, kept in storage during peacetime operations, at a

potential additional annual cost of \$430 million to maintain surge staffing. This alternative offers the military the highest level of immediate capability, with full compatibility using all military UAS and pilots. Minimal interoperability concerns exist in this solution, but the overall budget increase for surge capability would run \$500 million per year.

In addition to idle aircraft, an excess 460 contingency military UAS pilots in the dedicated military staffing model would require a means to maintain proficiency, necessitating a larger allocation for military training resources. A military-only fleet could potentially exist without the full complement of pilots, as general training times for military UAS pilots can occur in as little as six months. However, an excess of military pilots would still need to remain in place to absorb an initial surge phase while the initial training of new military UAS pilots takes place. Normal attrition from promotions, retirements, and separations further poses turnover and training concerns for a large standing military UAS pilot force.

Alternative 2: Interagency Augmentation

Interagency UAS assets can augment the US military in some combat or combat support operations. The CIA, CBP, and NASA own and operate UAS platforms similar or identical to those used by the armed forces, allowing common integration of datalink, mission functions, and command and control. Most notably, the CIA operates a fleet of Predator UAS with a long-standing history of military involvement. From early participation in the Balkans with the GNAT-750 to MQ-1 Predator missions over Pakistan, Yemen, and Iran, the CIA experience in UAS gives the military a viable interagency option to address contingency surge requirements. While the CIA does not publicly admit to targeted killing strikes with its UAS, it conducted 53 strikes in Pakistan in 2009 alone.⁶⁵ Despite the controversy surrounding the combatant role played by the CIA, the ISR support capabilities from its fleet can provide legal augmentation for

the military. The CIA operates a fleet of at least 30 MQ-1 Predators, flown by internal or military pilots; plans include an expansion of at least ten more aircraft.⁶⁶

The CBP and NASA unmanned fleets provide a limited source of capability for the military. With a fleet of ten MQ-9 Predator B aircraft operating from three border locations, the CBP logged over 18,000 UAS flight hours between 2011 and 2014.⁶⁷ While the CBP MQ-9 fleet provides direct compatibility for military operations, it has not previously been tasked to augment the military. However, the US government can task CBP UAS assets to fly missions for natural disaster relief or contingency monitoring.⁶⁸ Between 2010 and 2012, CBP Predator B aircraft flew 15 missions for the military.⁶⁹ As an additional interagency resource, NASA owns two RQ-4 Global Hawks and one MQ-9 Predator B for atmospheric research and mapping.⁷⁰ NASA also owns small Group 1 to 3 UAS that do not reasonably provide augmentation capability for the military.

Agency	Large UAS Inventory	Fleet Cost (\$ Million)	Pilots (Nominal Staffing)	Pilot Cost (\$ Million)
CIA	40 (Projected)	172	200	27.6
CBP	10	43.5	50	6.9
NASA	3	24.9 ⁷¹	15	2.1
Total	53	240.4	265	36.6
Note: CIA and CBP Fleet costs based on MQ-1 and MQ-9 NASA Fleet costs based on RQ-4 and MQ-9				

Table 5: Interagency UAS Inventory

Based on the projected combined CIA, CBP, and NASA UAS fleets, the military can receive a maximum interagency augmentation of 53 Group 4 and 5 unmanned aircraft staffed by 265 pilots. While this augmentation capability will reasonably grow in the long term future, the fifteen percent surge requirement of 101 UAS aircraft and 505 pilots would require nearly double the current interagency UAS fleet. Due to mission commitments, the CIA and CBP may not

relinquish a majority of their aircraft for military use. Based on NASA's previous commitments of its fleets to military operations, the military will likely have the full NASA UAS fleet available for a contingency surge. Therefore, based on 50 percent of CIA and CBP unmanned fleet availability and 100 percent NASA availability, the military could reasonably have access to 28 large UAS platforms and 140 pilots. The results in an equivalent military peacetime cost savings of nearly \$133 million in aircraft procurement and \$19.3 million in crew costs.

While the interagency UAS augmentation option provides the military with limited aircraft and crew relief for surge operations, interoperability concerns arise with the use of civilian UAS and pilots. The ongoing involvement of CIA Predators for strike missions creates legal implications regarding the combatant status of civilian personnel. In a report addressing Law of Armed Conflict (LOAC) considerations, Ryan Vogel writes, "even some of those who are fully on board with nearly every other aspect of drone warfare find themselves uneasy with civilian personnel performing a combat function... CIA operation of drones for lethal combat-type operations prompts some legal questions."⁷² To conservatively mitigate LOAC infringement, the assignment of civilian interagency personnel to military operations could only apply to combat support missions, to include ISR. As future capability permits, interagency assets can also perform combat or combat support airlift operations.

Alternative 3: CRAF Augmentation

The CRAF model provides the military with access to over 450 large passenger and cargo aircraft for contingency operations, which reached a peak fleet size of 1,126 in 2005.⁷³ Peacetime contracts with CRAF operators incentivize commercial carriers to enter into the agreement, which currently includes 20 airlines.⁷⁴ While all CRAF fleets consist of traditionally piloted aircraft, the future acquisition by civilian operators would permit the US government to use civilian UAS under the current model. The alternative solution to expand CRAF to include

UAS platforms capable of ISR specifically and other combat support missions would allow companies such as General Atomics, Northrop Grumman, Lockheed Martin, and Boeing to place their UAS inventory on the CRAF availability agreement.

The deployment stages of CRAF allow for rapid deployment of civilian resources within 24 to 48 hours with maximum flexibility and cost savings for the military. UAS platforms can self-deploy or transport via larger cargo aircraft to meet availability requirements worldwide. The current contract civilian market for UAS includes mature ISR and communications technology. By 2012, the General Atomics Predator B flew over 700 contract flights for civilian government agency customers.⁷⁵ Current R&D for transport UAS and retrofit of manned commercial aircraft will result in an expansion of UAS technology for mainstream civilian use, with excess capacity available for military contracts or CRAF activation.

Rapid implementation and mitigation of latency costs serve as key advantages for civilian contracting during contingency operations. The military continues to contract civilian UAS and personnel to augment its existing fleet, laying the groundwork for a future CRAF agreement. In 2007, General Atomics obtained two contracts for MQ-1 Predator and MQ-9 Reaper aircraft totaling \$88 million for aircrew, maintenance, and operations support.⁷⁶ In the same year, Northrop Grumman received \$102 million for RQ-4 Global Hawk contracts for forwarding deployed operations.⁷⁷ In the very first Global Hawk combat deployment, civilian contractors made up 56 of the 82 operations personnel, accounting for 68 percent of the team and 100 percent of the pilots for the first two years.⁷⁸ Since then, UAS contracts continue to parallel the current CRAF carrier voluntary airlift contracts. As civilian operators acquire UAS, the financial incentives to participate in CRAF will accelerate fleet growth.

Based on recent civilian contract data, the use of civilian CRAF assets and aircrews can result in operating costs of 30 percent of those of an all-military solution.⁷⁹ The majority of costs

savings stems from initial military R&D or other program commitments along with personnel training and salaries. The CRAF concept eliminates any start-up or latency costs, instead of paying an all-inclusive hourly rate for civilian services performed. The requirement to provide civilian aircraft and crews in as little as one day yields significant time and cost advantages.

15 Percent Surge Option	Large UAS Surge (Group 4 and 5)	Annual Contract Cost (\$ Million)	UAS Pilots Needed	Pilot Availability	Pilot Cost (\$ Million)
CRAF Augmentation	101	142	503	1 day	50.3
Military	101	430	503	120 days	69.8
Difference	0	298	0	119 days	19.5

Table 7: CRAF and Military Comparison

In comparison with an all-military augmentation surge solution, the number of aircraft and pilots needed remains constant. The readily available civilian pilot pool provides the military with surge pilots nearly four months sooner than a military training program. Additionally, the average annual salary of a civilian UAS pilot of \$100,000 nets a total contingency pilot cost savings of \$19.5 million compared to higher-paid military pilots.⁸⁰

Ongoing technology and airspace restriction improvements will allow for additional CRAF operators to emerge. Currently, in flight testing, the General Atomics' Certifiable Predator B UAS will revolutionize the UAS market as the first civilian UAS certified to fly in highly restrictive European Airspace.⁸¹ These UAS platforms will perform firefighting, humanitarian aid, flood relief, and border monitoring functions for civilian companies or government agencies. Additionally, the future availability of large hybrid airships such as the Airlander 10 provides an optimum solution for long range strategic transport. A fleet of up to 16 heavy hybrid unmanned airships can deliver cargo at three times the rate of 21 Air Force C-17

aircraft.⁸² As the technology matures, civilian adoption of UAS airships will fill the gap as a low-cost shipping alternative to sealift and more expensive heavy cargo airlift. Finally, the US will continue to ease UAS airspace restrictions to allow for future civilian operations. As the FAA integrates UAS into the National Airspace System (NAS), the civilian market will experience tremendous growth; by 2025, 103,776 new civilian UAS sector jobs and \$82.1 billion in economic contributions will result in mainstream UAS utilization and mature civilian UAS for possible military contracting and CRAF designation.⁸³

Interoperability presents the most significant limitation for implementing a UAS CRAF agreement. While civilian defense contractors can continue to accommodate military UAS augmentation requirements, the capabilities available limits those missions to ISR and communications. Moreover, similar legal implications of interagency partners apply to the use of civilian assets and personnel in combat or combat support operations. To complicate interoperability concerns, the chain-of-command structure does not translate to commercial operators or defense contractors. Therefore, all civilian participants must receive training, intelligence briefings, certify medical readiness, and have equipment issued for deployment scenarios.⁸⁴ Despite concerns of heavy involvement in contingencies and the risk of unlawful combatant status, the DOD deems civilian UAS pilots and support personnel as noncombatant participants in military operations.⁸⁵

CONCLUSIONS

The analysis of three potential alternatives to address future military UAS staffing requirements addresses feasibility of adoption and implementation. To meet future contingency surges, a dedicated UAS military fleet with military pilots, and interagency UAS fleet, or a CRAF UAS fleet offer possible solutions to augment combat support or airlift operations. Three evaluation criteria gauge each alternative and incorporate physical, financial, and legal

limitations: cost, personnel, and interoperability. The research acknowledges current involvement of civilian contractor and interagency assets in combat and combat support UAS missions. Moving forward, the military must balance capabilities and limitations; the evaluation criteria provide a tangible benchmark to achieve an optimum solution for UAS fleet mix.

Based on the significant operational restrictions and ambiguity of civilian participation in direct combat missions, the military should not consider civilian UAS or pilots for any air combat strike mission. While the DOD defines a civilian accompanying the military in combat as a noncombatant, the “direct or active role in hostilities” could change that classification to unlawful combatant.⁸⁶ Furthermore, any interagency involvement in UAS strike operations cannot exist under a published strategic vision. Therefore, the first conclusion from this analysis deems civilian UAS unsuitable for direct combat operations. Unarmed combat support missions to include ISR, communications or networking, and tactical airlift can operate with civilian assets and crews under the legality of indirect participation.

As the most significant restraint on future operations, the cost evaluation criteria limits the expansion and maintenance of a dedicated military UAS fleet flown by military pilots. The ideal of a robust large standing military without any civilian involvement does not exist under the current defense structure. In order to shift to a pure military solution, the costs associated with R&D, procurement, training, operations, and maintenance, would far exceed budgetary limitations. While the use of civilian interagency UAS assets provides some augmentation for military operations, their fleet size and availability can only accommodate up to half of the contingency surge requirement with all interagency UAS platforms in service. Since the majority of interagency aircraft would likely remain unavailable due to their own dedicated functions, this low-cost option could feasibly only provide a minor support role for wartime operations, such as the use of two NASA RQ-4 Global Hawks and one MQ-9 Predator B.

The projected availability of civilian UAS in the next decade will grow exponentially as the FAA lifts NAS restrictions. The projected \$82 billion private sector investment in UAS serves as a key indicator that the military can overcome some financial constraints by accessing civilian assets. Similar to the existing CRAF agreement for cargo and passenger airlines, the military can enter into contracts with civilian UAS operators to secure the necessary contingency surge aircraft as needed. Using the CRAF model, the military bears no R&D or procurement costs; upon activation, CRAF UAS would enter into military service on a contracted hourly rate that could save the military \$260 million annually in operating costs. Large civilian defense contractors, including Boeing, Northrop Grumman, and Lockheed Martin, could place their UAS platforms on the CRAF availability document to ensure military fleet requirements, in turn receiving preferential access to peacetime CRAF contracts. The current practice of granting contracts to CRAF participants incentivizes participation in the program and financially justifies low cost excess civilian capacity. The existing military contracts for General Atomics civilian ISR UAS platforms suggests a compatible structure for CRAF UAS implementation.

Personnel requirements share a direct relationship with budget constraints, historically resulting in the use of civilian pilots operating military UAS. From the first Global Hawk deployment in 2001 to Predator and Reaper missions operating overseas today, personnel shortages continue to plague the military. The Air Force now trains more UAS pilots than fighter pilots annually, signaling a strategic shift and commitment to future UAS expansion.⁸⁷ The authorized military end strength reduction of nearly one-half million members by 2017 presents significant staffing challenges for recruiting, training, and retaining UAS pilots. With a normal training timeline of four to six months, the standing corps of military UAS pilots will fall short of the contingency surge requirement of over 500 pilots. Similarly, interagency UAS pilots

can only accommodate up to half of the surge requirement in the unlikely event of 100 percent activation. At twenty percent availability, interagency partners could provide roughly 30 pilots.

The CRAF model for UAS, based on projected civilian expansion, can provide contingency staffing without training lag time. As a CRAF requirement, civilian operators must provide aircraft and crews within 24 to 48 hours. The training costs and timelines remain the responsibility of the civilian sector, which can retain pilots with competitive compensation packages. The 500 pilot military contingency surge capability represents less than one percent of the projected civilian UAS employee hiring that will take place in the US by 2025. A CRAF agreement with civilian UAS operators would allow for immediate access of pilots without placing an undue burden on civilian operations. In this construct, civilian pilots will operate their own aircraft on a per-hour contract. The CRAF model does not account for separate contracting of aircraft and pilots; the military use of civilian pilots would therefore only occur with the activation of civilian UAS platforms.

Interoperability concerns arise from the use of interagency and potential CRAF UAS assets. Military chain of command structure, training and equipping of civilians for combat zones, and civilian aircraft capabilities play a significant role in the feasibility of integration with military UAS operations. In an ideal fleet mix, a dedicated military UAS fleet would limit interoperability drawbacks to cross-compatibility challenges across the armed services. An interagency UAS fleet introduces command structure ambiguities, but the similar UAS fleet inventories would seamlessly integrate with military operations based on known operational capabilities. A CRAF UAS fleet presents the most variable interoperability challenge, as commercially available UAS may possess the necessary requisite capabilities without necessarily sharing compatible control, communications, or maintenance characteristics as their military counterparts. The problems stemming from chain of command exist today in other civil-military

operations; the effective mitigation of civilian command integration will rely on past practices, detailed planning documents, and recurrent training.

RECOMMENDATION

As UAS technology matures, the military must balance cost, staffing, and compatibility requirements to operate its unmanned aircraft. The analysis of three alternative potential solutions for future UAS implementation included a dedicated military UAS fleet, interagency augmentation, and the expansion of the CRAF program to include civilian UAS. Based on the evaluation criteria and constraints, the CRAF model offers the optimum solution to allow the military to meet its augmentation requirements in the event of a contingency. The cost-prohibitive nature of an all-military UAS fleet requires civilian augmentation, already evident in the past two decades of military operations. The CRAF structure, validated by more than half a century of vital contingency capacity for military personnel and cargo transport, offers a viable solution for incorporating civilian UAS assets.

The CRAF solution enables the military to contract for a variable guaranteed inventory of commercial UAS to account for future contingency requirements. The military benefits from bearing no R&D or procurement costs, paying only for contracted UAS operations. An added benefit from accessing civilian assets includes continual technological advancement. The military can gain access to the newest commercial fleets without investing in proprietary UAS technology that could become obsolete. A CRAF UAS fleet also includes civilian crews as part of the agreement, alleviating military concerns over training and retaining a large standing force of higher-cost pilots. Heavy investment in civilian UAS technology over the next decade will result in a large fleet of highly capable aircraft that can supplement military ISR, communications, networking, and airlift operations. The military should approach civilian operators to begin adding civilian UAS platforms to the CRAF agreement.

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